B2

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04B 7/005, H04Q 7/38 — A1

(11) International Publication Number: WO 99/16185

(43) International Publication Date: 1 April 1999 (01.04.99)

(21) International Application Number: PCT/SE98/01695

(22) International Filing Date: 22 September 1998 (22.09.98)

(30) Priority Data:
08/937,018 24 September 1997 (24.09.97) US

(71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON (publ) [SE/SE]; S–126 25 Stockholm (SE).

(72) Inventors: KNUTSSON, Jens; Mörbydalen 7, S–182 52 Danderyd (SE). PERSSON, Magnus; Kruthornsvägen 40, S–192 53 Sollentuna (SE).

(74) Agent: ERICSSON RADIO SYSTEMS AB; Common Patent Dept., S–164 80 Stockholm (SE).

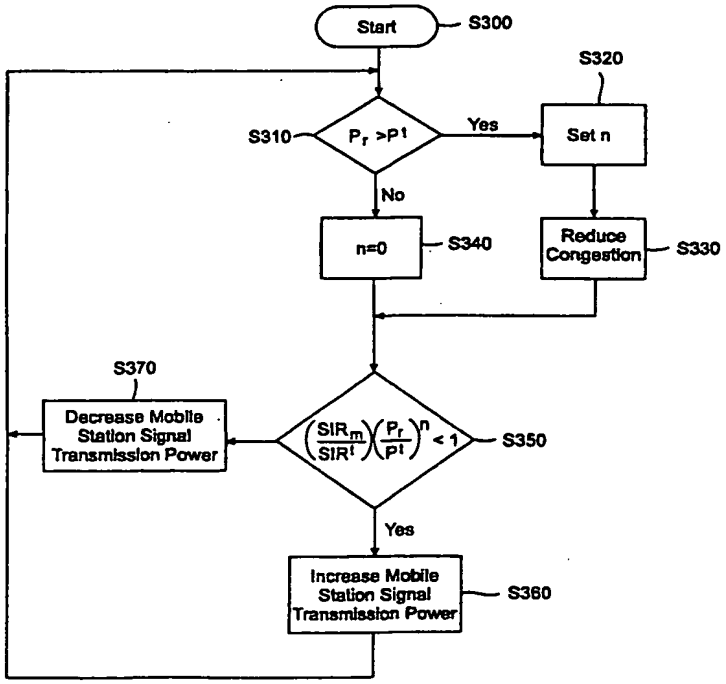
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: INTEGRATED POWER CONTROL AND CONGESTION CONTROL IN A COMMUNICATION SYSTEM

(57) Abstract

A method of stabilizing a communication system having base stations and mobile stations using integrated control of both signal transmission power levels and signal congestion levels. In particular, the method includes measuring a quality such as a signal to interference ratio of a signal transmitted from a mobile station to a base station and measuring a total received signal power at the base station. The signal transmission power of the mobile station is changed based on comparisons of the measured signals with predetermined threshold values. When the measured total received signal power at the base station exceeds the corresponding predetermined threshold value, a congestion control algorithm is executed to reduce the signal congestion level.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

INTEGRATED POWER CONTROL AND CONGESTION CONTROL IN A COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to the control of power and traffic levels of transmitted signals in telecommunication systems, in particular spread spectrum. or code division multiple access (CDMA) systems.

In a typical CDMA system, an information data stream to be transmitted is impressed upon a much-higher-bit-rate data stream produced by a pseudo-random code generator, such that each information signal is allocated a unique code. A plurality of coded information signals are transmitted as modulations of radio frequency carrier waves and are jointly received as a composite signal at a receiver. Each of the coded signals overlaps all of the other coded signals. as well as noise-related signals, in both frequency and time. By correlating the composite signal with one of the unique codes, the corresponding information signal can be isolated and decoded.

In a mobile radiotelephone system, interference between different call connections using the same radio channel can be reduced by regulating the transmission power levels of mobile stations and base stations in the system. Preferably, only the transmission power necessary to maintain satisfactory call quality is used to reduce the likelihood of interference between calls using the same radio channel. An attribute such as a signal-to-noise interference ratio (SIR) can be used as

a measure of quality or power of received signals in the system, i.e., as one measure of call quality in the system. The each connection between a mobile station and a base station can have a SIR, and SIR measures of different connections can be different.

By regulating power in communication systems that use CDMA so that only the transmission power necessary to maintain satisfactory call quality is used, capacity of the system can be increased by approximately 70% as compared with an unregulated system where signal transmission power is unnecessarily large, assuming that all of the calls or connections have the same SIR target or required SIR. In addition, mobile stations in the system consume less energy when transmit power levels are maintained at a lowest possible level. Accordingly, batteries used to power mobile stations can have a smaller capacity, allowing the mobile stations to be lighter in weight and smaller in size.

One known type of power control is so-called "fast" SIR-based control. The basic principle of fast SIR-based control of signal transmission power is that under normal conditions, an increase in signal transmission power will cause a corresponding increase in SIR. In fast SIR-based control, when the SIR of the signal transmission is higher than necessary, the signal transmission power is decreased. When a SIR of a signal transmission from a mobile station to a base station is too low, the signal transmission power of the mobile station is increased. Precise details regarding fast-SIR based control of signal transmission power in CDMA systems will be apparent to those skilled in the art, and are not discussed in this document.

When a mobile communication system is overloaded, signal transmissions within the system can mutually interfere. In such a scenario, increasing signal

transmission power does not effectively increase the SIR because of "party effects".

The party effect phenomenon is similar to what happens at a party when people talking with each other speak loudly to hear over others who are speaking loudly, thus causing the overall noise level to become large. Specifically, in a system employing fast SIR-based control of signal transmission power, a first mobile station experiencing a SIR that is below a SIR target value or threshold will increase signal transmission power to bring the SIR to the target value. If the interference that the first mobile station is trying to overcome is caused by signal transmissions from a second mobile station, and signal transmissions from the first and second mobile stations are mutually interfering, then the signal transmission power increase by the first mobile station can cause a corresponding increase in interference with the second mobile station's signal transmission and degrade the second mobile station's SIR below its target value. In response the second mobile station will increase its signal transmission power to increase its SIR, thus exacerbating the original problem. Positive feedback is present in the system, and the mobile stations will each increase signal transmission power until maximum power levels are reached, without achieving the desired quality or power of the received signals. Party effects arising in one cell of the system can spread to neighboring cells in the system when, for example, high signal transmission power levels in the one cell interfere excessively with signal transmissions in an adjacent cell.

U.S. Patent No. 5,574,982 to Almgren et al ("Almgren") provides a solution to avoid party effects in cellular radio communication systems. Almgren is incorporated by reference into this document. Almgren describes monotonically

reducing a target carrier-to-interference ratio (C/I) or SIR as signal transmission power is increased. Thus, as signal power is increased to compensate for interference, the allowable level of interference is also increased. In effect, the system avoids the large reduction in signal quality of all users in the same cell that would result from party effects by tolerating a smaller reduction in signal quality, i.e., by increasing the allowable level of signal interference. However, although party effects are avoided, signal quality is nevertheless reduced.

Problems can arise, however, in a system having a slow, quality-based power control in addition to a fast, closed loop SIR-based power control that uses the method described in Almgren. In such a system, when an experienced signal quality (typically, a frame error rate) decreases below an acceptable value, e.g., when the system is overloaded, the slow power control will increase the SIR target by increasing the value of a specified SIR threshold. In contrast, the fast, SIR-based power control will effectively decrease the SIR target as signal power is increased to remedy the reduction in signal quality. Thus, the system suffers from the disadvantage that the slow power control and the fast power control can counteract each other because they both alter the SIR target in different directions. Consequently, the fast power control can only temporarily stabilize the system.

M. Andersin, in "Power Control and Admission Control in Cellular Radio Systems", Ph.D. thesis, Royal Institute of Technology, Stockholm, Sweden, May 1996, describes a system wherein control of signal transmission power is integrated with removal of signal connections. The integration is achieved by performing fast, closed loop SIR-based control of signal transmission power only for supported signal

connections, and deactivating all other (i.e., unsupported) signal connections by setting their respective signal transmission powers to zero. A supported signal connection is a signal connection whose SIR target can be achieved within the system. In contrast, an unsupported signal connection is a signal connection whose SIR target cannot be achieved within the system. Connection removal algorithms are used to select specific connections which can be removed to stabilize the system.

In other words, the SIR-based power control algorithm is not altered based on signal traffic congestion levels within the system. Instead, the set of signal connections controlled by the SIR-based power control algorithm is altered. The connection removal algorithm removes signal connections until remaining signal connections can each achieve their SIR targets under the control of the SIR-based power control algorithm. Such an integrated control will cause a communications system to a) require additional signaling over the air interface, since knowledge of the output power of the mobile stations is needed; b) require more complex infrastructure for the mobile stations and the base stations since the fast closed loop power control cannot be applied when deactivating some connections; and c) be unable to protect real time services in the deactivation phase.

SUMMARY OF THE INVENTION

The invention overcomes disadvantages of the foregoing techniques by providing integrated control of both signal transmission power and signal traffic congestion, e.g., data transfer rate, in a CDMA communications system. In a CDMA communications system wherein some users might not require real-time

communication, the signal transmission power is controlled based on a) a measured signal quality, such as SIR, and b) a level of signal traffic congestion within the system. A total signal power received at a base station in the system can provide a measure of signal traffic congestion. Congestion control can be performed, for example, based on the total signal power received at the base station. Congestion control can include reducing signal traffic congestion from a first level to a second level by lowering the transmission bit rate for those users that do not require real-time communication, performing an interfrequency handover, or terminating communications between at least one mobile station and the base station.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and objects of the invention will be understood by reading this description in conjunction with the drawings, in which:

FIG. 1 is a block diagram of a CDMA communication system according to an embodiment of the invention;

FIG. 2 illustrates internal configurations of a base station and a mobile station shown in FIG. 1;

FIG. 3 is a flow diagram illustrating signal transmission power control and congestion control according to a first embodiment of the invention; and

FIG. 4 is a flow diagram illustrating signal transmission power control and congestion control according to a second embodiment of the invention.

DETAILED DESCRIPTION

FIG. 1 shows a CDMA communications system having cells C1-C7, wherein each cell includes one of the base stations B1-B7 and one or more of the mobile

stations M11-M71. The base stations and mobile stations can have an internal configuration as shown in FIG. 2, where the base station B1 and the mobile station M11 each have a processor 200, 250, a transmitter 210, 240 and a receiver 220, 230 respectively.

According to an aspect of the invention, when a cell in the system enters an unstable or overloaded state, for example when signal transmission power levels become too high and/or SIR levels become too low, a power control algorithm avoids party effects by simultaneously lowering signal transmission quality targets or thresholds and adjusting signal transmission power, thus stabilizing the power vector, i.e., stabilizing signal transmission power levels within the system. Congestion control is also activated to reduce a level of signal traffic by either delaying, transferring to another frequency, or terminating a user's communications. The congestion can be controlled while the power control algorithm is stabilizing the power vector, or after the power vector has been stabilized. Thus, the power control algorithm stabilizes the power vector, and the congestion control reduces the signal traffic in the cell until the system is back in a stable state and the transmission quality targets or thresholds are restored to acceptable levels. Suitable processors located in base stations and/or mobile stations of the system can perform the power and congestion control functions.

Congestion can be reduced from a first level to a second level by selecting a signal transmission between a mobile station and a mobile station within the cell, and then lowering the bit transmission rate of the signal transmission. Alternatively, an interfrequency handover can be performed to shift the selected signal transmission to a different frequency to reduce congestion on the original frequency, or the selected

signal transmission can be terminated. According to an embodiment of the invention, lowering the bit transmission rate is preferable to shifting the selected signal transmission to a different frequency, which is in turn preferable to terminating the signal transmission.

Situations where the bit rate is not lowered can include, for example, the situation where the bit rate is already at a minimum rate specified either by the system, or by user requirements (e.g., when the data carried by the signal transmission represent a real time voice communication between people and lowering the bit rate would unacceptably hinder the communication). If the bit rate is not lowered or if lowering the bit rate does not sufficiently reduce congestion, then frequency handover or termination can be considered.

If other signal frequencies are also congested or otherwise unavailable, then it may not be possible to change the frequency of the selected signal transmission. In that situation, the signal transmission can be terminated in order to reduce congestion.

Signal transmissions can be selected for bit rate reduction, frequency handover, or termination based on a variety of factors, including: a) whether real-time delivery of data via a particular signal transmission is required or desired, b) current transmission bit rates of various signals, c) the priority of a particular signal transmission over other signal transmissions, d) availability of other frequency channels, and e) relative contribution to congestion by a particular signal transmission. As those of ordinary skill in the art will recognize, suitable processors located in base stations and/or mobile stations of the system can be used to make these determinations and perform congestion control. Further details regarding techniques for reducing

congestion will also be apparent to those of ordinary skill in the art. and are not described in this document.

When the power control algorithm is properly chosen, party effects can be confined to a particular cell, which means that sources of instability can easily be found and taken care of. In addition, if the power vector is stable when the congestion control alters one user's communications within the cell, then a resulting change in congestion can be rapidly detected and communications of other users within the cell are less likely to be altered or disrupted by the congestion control.

According to an exemplary embodiment of the invention, signal transmission power of a mobile station is increased when the following condition is true:

$$(SIR_m/SIR^t)*((P_r/P^t)^n) < 1$$

where SIR_m is a SIR measured, e.g., by the base-station. SIR^t is a specified SIR threshold, P_r is a total power received at the base station. P^t is a chosen threshold, and n is a chosen coefficient. When the condition is false, signal power of the mobile station is decreased. Those skilled in the art will recognize that the threshold for total received power at the base station, P^t, can be chosen for a particular system by testing the system with different values of P^t, and then selecting a value that yields satisfactory performance. Those skilled in the art will also note that when $n = 0$, the algorithm describes ordinary SIR-based fast power control. When n is greater than zero, the algorithm effectively reduces the SIR target as signal transmission power increases. In an embodiment of the invention, values for n are chosen based on a comparison between P_r and P^t. When P_r is less than the threshold value P^t, n is chosen to be 0. When the total signal power P_r received at the base station exceeds the

threshold value P^t, n is set to a value greater than zero, for example between about 0.2 and about 0.3, thus effectively lowering the target SIR as signal transmission power of a mobile station is increased. In addition, congestion control is activated when P_r exceeds the threshold value P^t. The congestion control forces the system back into a stable state where P_r does not exceed P^t. The fast power control only alters the SIR target during a very short amount of time in which the fast power control and the congestion control stabilize the system.

This technique is particularly advantageous in a system using a slow, quality-based power control in addition to a fast, SIR-based power control such as that described in Almgren. This is because according to the invention, the SIR target is altered for only a relatively short time, which is too short for the slow power control to react and attempt to increase the experienced signal quality by increasing the SIR threshold, SIR^t. Quality measurements in the quality-based power control can also be disregarded during a short period of time when n is greater than zero. Thus, in the invention fast power control and slow power control work together and not at cross-purposes.

Fig. 3 is a flow diagram showing a method for controlling congestion and transmission signal power according to a first embodiment of the invention. The method begins at step S300, and proceeds to step S310. In step S310, a determination is made whether P_r is greater than P^t. If P_r is greater than P^t, then n is set equal to 0.25 in step S320, and the method moves from step S320 to step S330. In step S330, congestion is reduced. From step S330, the method moves to step S350 where a determination is made whether a condition such as:

$$(SIR_m/SIR^t)*((P_r/P^t)^n) < 1$$

is satisfied. If the condition is not satisfied, then the method moves from step S350 to step S370, where the mobile station signal transmission power is decreased. From step S370 the method moves back to step S310, and the process repeats. If the condition is satisfied, then the method moves from step S350 to step S360, where mobile station signal transmission power is increased. From step S360 the method moves to step S310. If at step S310 P_r is determined to be less than P^t, then the method moves from step S310 to step S340, where n is set equal to zero. From step S340 the method moves to step S350, and proceeds as described above.

Fig. 4 is a flow diagram showing a method for controlling congestion and transmission signal power according to a second embodiment of the invention. The method begins at step S400 and proceeds to step S420, where a determination is made whether P_r is greater than P^t. If yes, then n is set equal to 0.25 in step S430. If no, then n is set equal to zero in step S440. From each of steps S430 and S440 the method moves to step S450. In step S450, a determination is made whether a condition such as:

$$(SIR_m/SIR^t)*((P_r/P^t)^n) < 1$$

is satisfied. If the condition is satisfied, then the method proceeds to step S460 where mobile station signal transmission power is increased. From step S460 the method moves to step S480. If the condition is not satisfied in step S450, then the method moves to step S470, where the mobile station signal transmission power is decreased. From step S470, the method moves to step S480, where a determination is made whether a convergence criterion is satisfied. If the convergence criterion is not

satisfied, then the method moves from step S480 to step S420 and the cycle repeats. The convergence criterion is a measure of how rapidly the total power received at the base station, P_r, is changing during a time Δt. For example, the convergence criterion can be:

$$|P_r(t) - P_r(t - \Delta t)| < \epsilon$$

where $P_r(t)$ is the total power received at the base station at a time t, and ϵ is a chosen value or threshold. If in step S480 the convergence criterion is satisfied, then the method moves from step S480 to step S490, where a determination is made whether P_r is greater than P^t. If P_r is greater than P^t, then the method moves to step S495, where congestion is reduced. From step S495, the method moves to back to step S420, and the process repeats. If in step S490 P_r is determined to be less than P^t, then the method moves directly back to step S420.

It will be understood that Applicant's invention is not limited to the particular embodiments described above and that modifications may be made by persons skilled in the art. The scope of Applicant's invention is determined by the following claims, and any and all modifications that fall within that scope are intended to be included therein.

What is claimed is:

1. A method of controlling a communication system having base stations and mobile stations, comprising the steps of:

controlling signal transmission power of at least one station in the system based on a signal traffic congestion in the system;

measuring a received signal power at one of the base stations;

comparing the measured signal power with a first threshold value; and

controlling the signal traffic congestion in the system based on the comparison of the measured signal power with the first threshold value.

2. The method of claim 1, wherein the step of controlling congestion comprises:

performing at least one of lowering a bit rate of signal transmission between a first mobile station and a first base station, performing an interfrequency handover of signal transmissions between the first mobile station and the second base station, and terminating the signal transmission between the first mobile station and the first base station.

3. The method of claim 1, wherein the step of controlling signal transmission power comprises:

measuring a quality of a signal transmitted from one of the mobile stations to the one base station;

comparing the measured quality with a second threshold value; and

changing the signal transmission power of the one mobile station based on the comparisons of the measured values with the threshold values.

4. The method of claim 3, wherein the signal transmission power of the one mobile station is increased when a) $(SIR_m/SIR^t) < 1$ and $P_r < P^t$, or b) $(SIR_m/SIR^t)((P_r/P^t)^n) < 1$ and $P_r > P^t$, wherein:

SIR_m is a signal to interference ratio measured at the one base station of a signal transmitted from the one mobile station;

SIR^t is a predetermined signal to interference ratio threshold value;

P_r is a total signal power received at the one base station;

P^t is a predetermined total received signal power threshold value; and

n is greater than zero.

5. The method of claim 4, wherein n is between about 0.2 and about 0.3.

6. The method of claim 4, wherein the step of controlling congestion is performed when $P_r > P^t$ and comprises the steps of:

selecting a signal transmission between a first mobile station and a first base station;

performing at least one of lowering a bit rate of the selected signal transmission, executing an interfrequency handover of the selected signal transmission, and terminating the selected signal transmission; and

repeating the steps of selecting and performing until $P_r < P^t$.

7. The method of claim 6, wherein the signal transmission is selected based on whether delivery of data via the signal transmission is desired in real time.

8. The method of claim 6, wherein the step of performing is prioritized such that lowering the bit rate of the signal transmission and executing an interfrequency handover are preferred over terminating the selected signal transmission.

9. The method of claim 6, wherein the step of performing is prioritized such that lowering the bit rate of the signal transmission is preferred over executing an interfrequency handover.

10. A method of stabilizing a communication system having base stations and mobile stations, comprising the steps of:

reducing signal traffic congestion from a first level to a second level;

stabilizing a power vector of the system based on the signal traffic congestion; and

repeating the steps of stabilizing the power vector and reducing signal traffic congestion until a total signal power received at the one base station is less than a first threshold value.

11. The method of claim 10, wherein the step of stabilizing the power vector comprises the steps of:

measuring the total signal power received at the one base station;

comparing the measured signal power with the first threshold value;

measuring a quality of a signal transmitted from one of the mobile stations to one of the base stations;

comparing the measured quality with a second threshold value; and

changing the signal transmission power of the one mobile station based on the comparisons of the measured values with the threshold values;

12. The method of claim 11, wherein the step of reducing congestion comprises:

when the measured total signal power received at the one base station is greater than the first threshold value, selecting a signal transmission between a first mobile station and a first base station and performing at least one of lowering a bit rate of the selected signal transmission, performing an interfrequency handover of the selected signal transmission, and terminating the selected signal transmission.

13. An apparatus for stabilizing a communication system having base stations and mobile stations, comprising:

means for stabilizing a power vector of the system based on signal traffic congestion in the system; and

means for reducing congestion in the system from a first level to a second level by selecting a signal transmission between a first mobile station and a first base station and performing at least one of lowering a bit rate of the selected signal

transmission, performing an interfrequency handover of the selected signal transmission, and terminating the selected signal transmission.

14. The apparatus of claim 13, wherein the means for stabilizing a power vector of the system comprises:

means for measuring a total signal power received at one of the base stations;

means for comparing the measured signal power with a first threshold value;

means for measuring a quality of a signal transmitted from one of the mobile stations to the one base station;

means for comparing the measured quality with a second threshold value; and

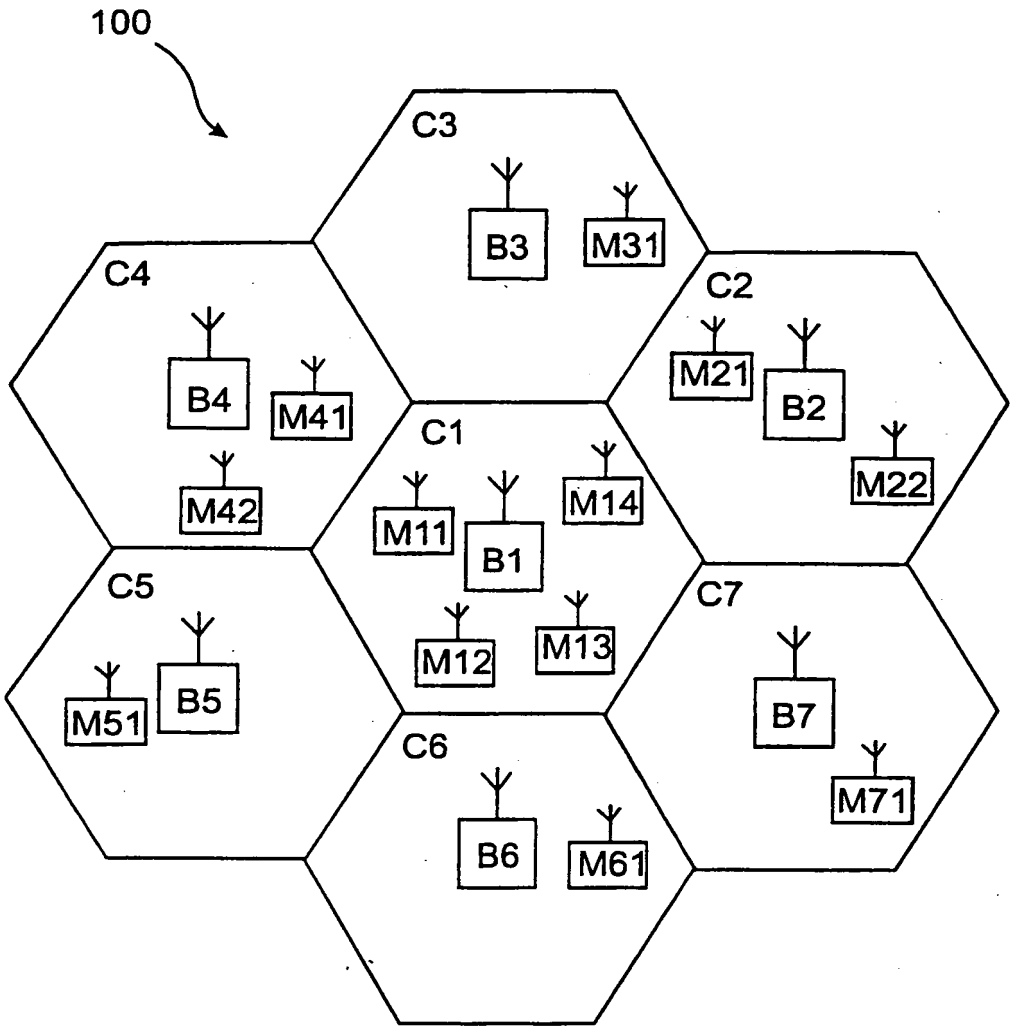
means for changing the signal transmission power of the one mobile station based on the comparisons of the measured values with the threshold values.

15. The apparatus of claim 14, wherein the means for stabilizing comprises a processor located at one of the stations.

16. The apparatus of claim 14, wherein the means for reducing congestion comprises a processor located at one of the stations.

17. The apparatus of claim 14, wherein the means for reducing congestion reduces congestion based on the comparison of the measured signal power with the first threshold value.

Fig. 1


100
C3
B3
M31
C4
B4
M41
M42
C2
M21
B2
M22
C1
M11
B1
M14
M12
M13
C5
M51
B5
C7
B7
M71
C6
B6
M61

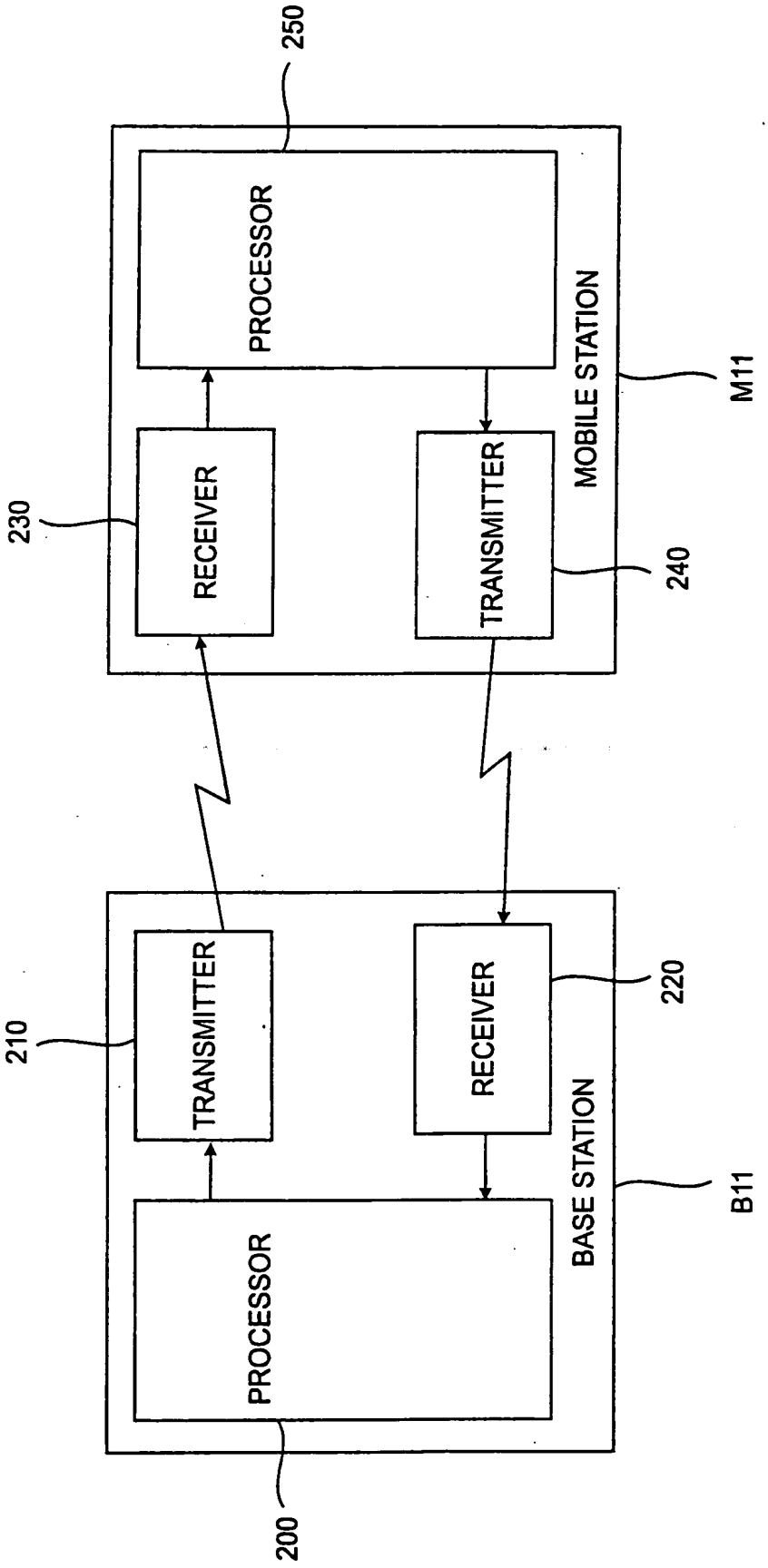

250
PROCESSOR
MOBILE STATION
M11
230
RECEIVER
TRANSMITTER
240
210
TRANSMITTER
RECEIVER
220
BASE STATION
B11
PROCESSOR
200

Fig. 2

Fig. 3

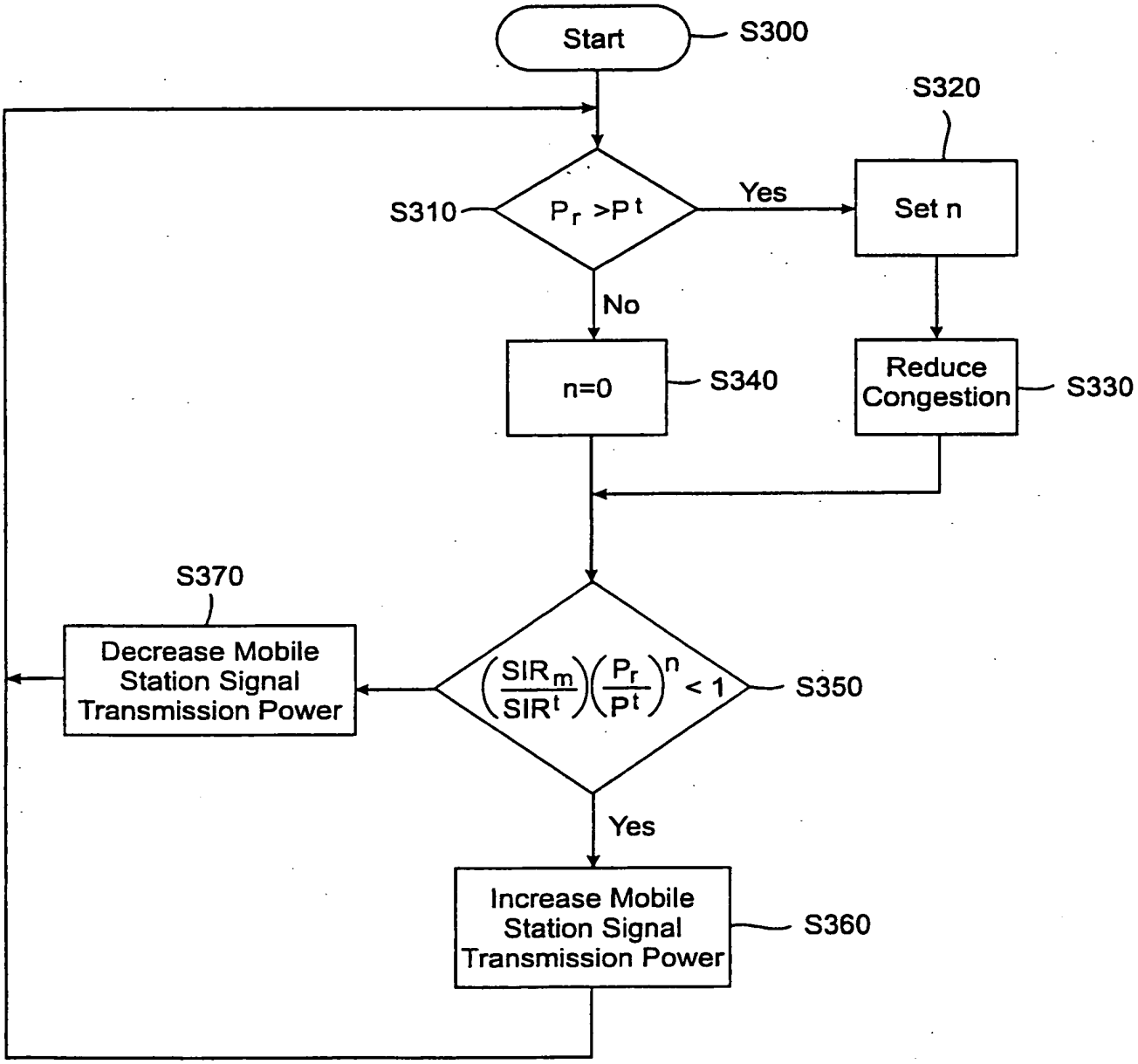
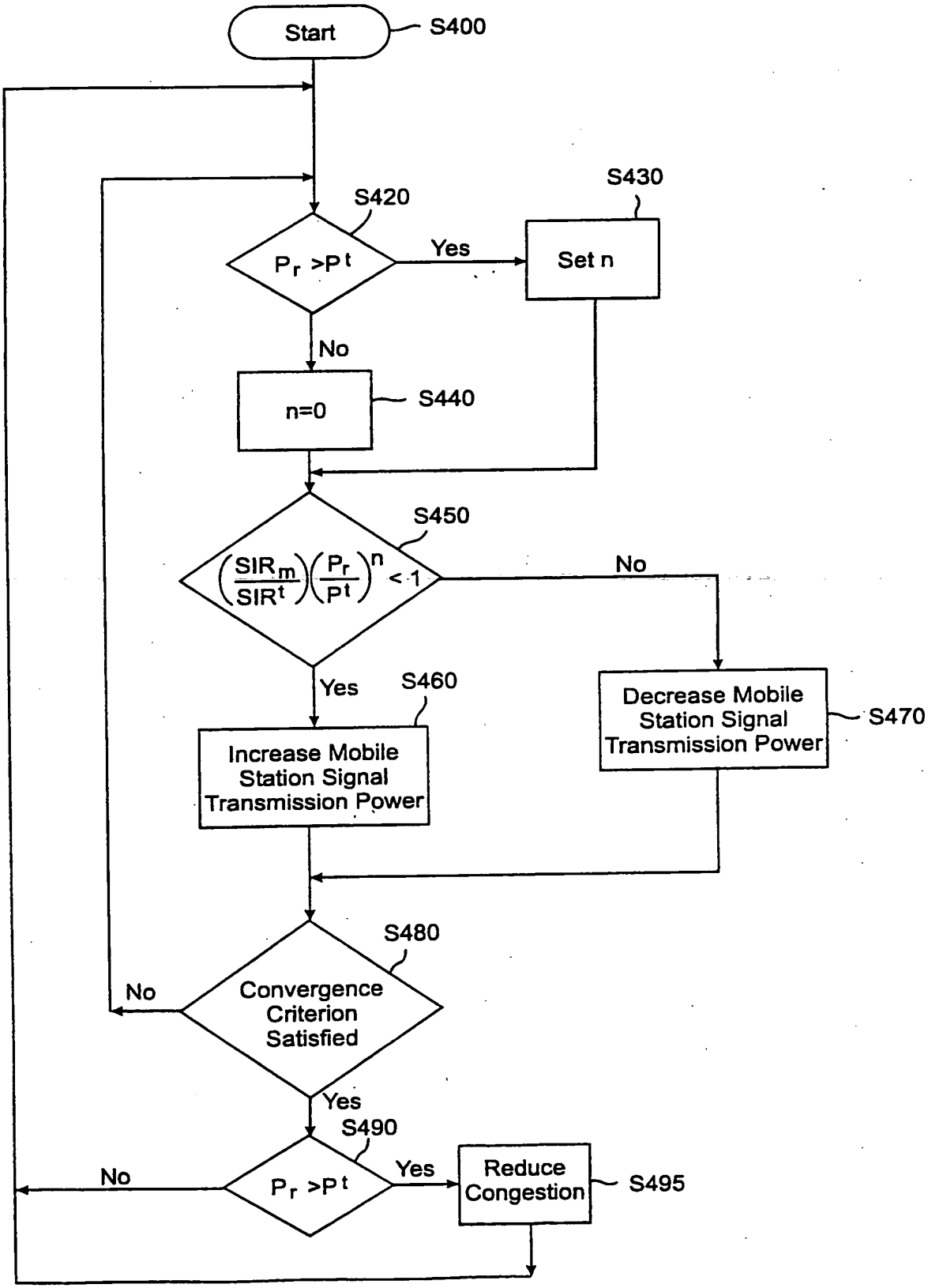

Start
S300
S320
S310
$P_r > P^t$
Yes
Set n
No
n=0
S340
Reduce Congestion
S330
S370
Decrease Mobile Station Signal Transmission Power
$\left(\frac{SIR_m}{SIR^t}\right)\left(\frac{P_r}{P^t}\right)^n < 1$
S350
Yes
Increase Mobile Station Signal Transmission Power
S360

Fig. 4


Start
S400
S420
$P_r > P^t$
Yes
S430
Set n
No
n=0
S440
S450
$\left(\frac{SIR_m}{SIR^t}\right)\left(\frac{P_r}{P^t}\right)^n < 1$
No
Yes
S460
Increase Mobile Station Signal Transmission Power
Decrease Mobile Station Signal Transmission Power
S470
S480
Convergence Criterion Satisfied
No
Yes
S490
$P_r > P^t$
No
Yes
Reduce Congestion
S495

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/SE 98/01695

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04B7/005 H04Q7/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04B H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0 762 668 A (NOKIA TELECOMMUNICATIONS OY) 12 March 1997 see abstract see column 1, line 17 - column 2, line 9 see column 6, line 27 - line 58 see column 9, line 9 - line 30 see claims 1-7; figures 1-3	1-17
Y	EP 0 713 300 A (MOTOROLA LTD) 22 May 1996 see abstract see column 1, line 10 - line 30 see claims 1-7; figures 3,12	1-17

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 December 1998	22/12/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Lazaridis, P

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/SE 98/01695

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 475 861 A (HALL SCOTT M) 12 December 1995 see abstract see column 1, line 21 - column 2, line 13 see column 6, line 9 - line 65 see figure 8 ---	1-3,10, 13
A	US 5 574 982 A (ALMGREN MAGNUS K ET AL) 12 November 1996 cited in the application see abstract see column 1, line 1 - column 2, line 43 see column 4, line 26 - line 50 see claim 1; figures 2,4,5 -----	1,3,4

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter nal Application No
PCT/SE 98/01695

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0762668 A	12-03-1997	WO 9708847 A	06-03-1997
		AU 3260195 A	19-03-1997
		AU 6429196 A	06-03-1997
		CN 1148756 A	30-04-1997
		JP 9139712 A	27-05-1997
		NO 963640 A	03-03-1997
		US 5839056 A	17-11-1998
EP 0713300 A	22-05-1996	GB 2295295 A	22-05-1996
US 5475861 A	12-12-1995	BR 9305565 A	26-12-1995
		CA 2116131 A,C	20-01-1994
		CN 1086944 A,B	18-05-1994
		EP 0602236 A	22-06-1994
		FI 940983 A	01-03-1994
		IL 106184 A	14-11-1996
		JP 6510657 T	24-11-1994
		KR 9703530 B	18-03-1997
		MX 9303984 A	28-02-1994
		SG 46375 A	20-02-1998
		WO 9401943 A	20-01-1994
US 5574982 A	12-11-1996	AU 675849 B	20-02-1997
		AU 6810094 A	12-12-1994
		CA 2139768 A	24-11-1994
		CN 1109700 A,B	04-10-1995
		EP 0650647 A	03-05-1995
		FI 950157 A	13-01-1995
		JP 8500228 T	09-01-1996
		WO 9427380 A	24-11-1994
		SG 52335 A	28-09-1998